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**Exhaust heat exchanger, in particular
for motor vehicles**

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The invention relates to an exhaust heat exchanger in particular for motor vehicles having an exhaust gas recirculation system (AGR), composed of a housing jacket for a coolant, and of a nest of pipes through which exhaust gas flows on the inside and around which coolant flows on the outside and which is held in the housing jacket by means of pipe plates, the nest of pipes, pipe plates and housing jacket forming an enclosed force flux - such an exhaust heat exchanger has been disclosed by DE-A 199 07 163 by the applicant.

This known exhaust heat exchanger is an exhaust gas radiator such as is used in motor vehicles for recirculating exhaust gases in order to cool the hot exhaust gases. The exhaust gas radiator which is manufactured from stainless steel is essentially composed of a housing with a housing jacket through which a coolant flows, said coolant being removed from the coolant circuit of the internal combustion engine of the motor vehicle. A nest of pipes whose pipe ends are held by pipe plates which are themselves connected to the housing jacket is arranged in the housing jacket. The pipe ends are welded tightly to the pipe plates and the pipe plates are welded at the circumference to the housing jacket. In this respect the two pipe plates form, together with the housing jacket, what are referred to as fixed bearings. When this exhaust gas radiator operates, the pipes and housing jacket heat up to differing degrees because the exhaust gases flowing through the pipes have a higher temperature than the coolant flowing around the housing jacket. As a result, different degrees of expansion

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between the nest of pipes and the housing jacket occur, which leads to thermally induced stresses, i.e. compressive stresses in the pipes and tensile stresses in the housing jacket and flexural stresses in the pipe plates. The pipes of the nest of pipes which form the pipe plates, which hold the pipe ends, and the housing jacket thus form an enclosed force flux in which the pipes are supported on the housing jacket by means of the pipe plates. In particular in the case of exhaust gas radiators with a long length, such as are used in utility vehicles, the stresses which occur owing to the different degrees of expansion can lead to individual components failing or to the connection between the pipe plates being destroyed.

The object of the present invention is to reduce these thermally induced stresses, i.e. to decrease the resulting stresses in the components of the exhaust heat exchanger in order to achieve higher safety and a longer service life for the exhaust heat exchanger mentioned in the beginning.

The means of solving this object is proposed according to claim 1 in that a sliding fit is arranged within each force flux, i.e. a fit between two components which can slide in relation to one another, that is to say what is referred to as a loose bearing, in contrast to a fixed bearing such as is present in the prior art of the generic type. Such a sliding fit compensates for the different degrees of expansion of the nest of pipes and housing, i.e. the abovementioned stresses do not occur at all. The sliding fit can be installed structurally at any desired location of the force flux, it being necessary where possible to avoid the coolant and exhaust gas becoming mixed with one another, which could lead to damage to the engine.

According to one advantageous development of the

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invention, the sliding fit is arranged in the housing. This solution has the advantage that relatively large sliding surfaces are available and that there is no risk of coolant becoming mixed with the exhaust gas, or vice versa when there is a leakage due to the sliding fit. The housing jacket is divided transversely with respect to the direction of the force flux, and both housing parts are assembled in a telescopic fashion so that when the nest of pipes experiences severe expansion they can be pulled apart from one another without stresses occurring in the housing jacket, in the pipe plate or in the nest of pipes.

According to one advantageous development the sliding fit is composed of an outer ring and an inner ring between which a plastic sliding layer is arranged in order to improve the sliding properties. Both rings are pushed onto the end regions of the housing parts of the prefabricated sliding fit, and preferably bonded to said housing parts. The bonding avoids excessive application of heat and thus possible distortion of the components. The fitting on and bonding of the internal ring and outer ring is advantageous in particular when the housing jacket has a somewhat rugged contour: the surfaces of the inner and outer ring which slide one on the other can be configured as simple contours which can be sealed satisfactorily, for example, as a polygonal contour.

According to one advantageous development of the invention, the sliding fit is arranged between one of the two pipe plates and the housing. This solution thus provides a fixed bearing and a loose bearing for the nest of pipes. As a result, the nest of pipes can expand freely with respect to the housing jacket so that the abovementioned compressive stresses do not occur in the pipes and the abovementioned tensile stresses do not occur in the housing jacket. The pipe

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plate which is embodied as a sliding fit thus has a sliding surface which slides along an assigned sliding surface of the housing jacket and is sealed with respect thereto, preferably by means of O rings.

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According to one development of the invention, a drainage, which is connected to the atmosphere, is provided between the O rings, i.e. between two O rings. This drainage provides the advantage that the coolant and exhaust gas cannot mix if an O ring or a corresponding seal fails because either the exhaust gas or the coolant escape to the outside through the drainage.

15 According to one advantageous development, the drainage is embodied as a slit in the housing, i.e. the housing is divided by a joint and is held spaced apart by means of spacer sleeves which are arranged on the circumference. If the seal fails, exhaust gas or coolant can be conducted away to the outside through the slit.

According to one advantageous alternative, the drainage is formed between two O rings as an annular groove in which the leakage fluid or the leakage gas collect and can escape to the outside via drainage openings which are arranged in the annular groove. This solution is structurally simple since the housing does not need to be divided.

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Exemplary embodiments of the invention are illustrated in the drawing and will be described in more detail below. In said drawing:

35 fig. 1: shows a perspective view of an exhaust gas radiator with a sliding fit in the housing jacket,

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fig. 2 shows the exhaust gas radiator according to fig. 1 in a longitudinal section,

5 fig. 2a shows a side view of the exhaust gas radiator according to fig. 2,

fig. 2b shows a section through the exhaust gas radiator according to fig. 2 in the sectional plane I Ib-I Ib,

10 fig. 2c shows the sliding fit as an individual unit,

fig. 3 shows a further embodiment of an exhaust gas radiator with the sliding fit between the pipe plate and housing jacket,

fig. 4 shows a section through the exhaust gas radiator according to fig. 3 in the plane IV-IV,

20 fig. 5 shows a modification of the exhaust gas radiator according to fig. 3 with the drainage groove, and

25 fig. 6 shows a schematic view of the stresses in an exhaust gas radiator according to the prior art.

30 Firstly, fig. 6 shows the stress conditions in an exhaust gas radiator according to the prior art which is cooled by coolant. This schematic illustration corresponds to an exhaust gas radiator according to the prior art by the applicant which is mentioned at the beginning. Such a known heat exchanger 60 is composed of a housing jacket 61 which holds a nest of pipes 35 which is composed of pipes 62 and whose ends are held in pipe plates 63, 64. The pipes 62 are connected at both ends to the pipe plates 63, 64 in a secure and

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sealed fashion, for example, by means of welded connections. The pipe plates 63, 64 are securely connected to the housing jacket 61 at the circumference by means of welded connections 65, 66. In this way, both pipe plates 63, 64 form two fixed bearings with the housing jacket 61. When such an exhaust gas radiator 60 is operating, the hot exhaust gas flows through the pipes 62, while coolant at a considerably lower temperature is applied to the inside of the housing jacket 61. As a result, different degrees of expansion between the pipes 62 and the housing jacket 61 are produced. For this reason, compressive stresses, which are characterized by arrows and the letter C (compression) which are directed one against the other are formed in the pipes 62. These compressive stresses continue further to the housing jacket 61 via the pipe plates 63, 64 and the welded connections 65, 66, tensile stress, characterized by the letter T (tension) and arrows pointing away from one another, then building up in the said housing jacket 61. The tensile stresses T and the compressive stresses C thus form an enclosed force flux or force flux ring over the pipe plates 63, 64 in which flexural and shearing stresses (not illustrated) occur.

Fig. 1 shows a perspective view of an exhaust gas radiator 1 for a motor vehicle with an exhaust gas recirculation system (AGR). Such exhaust gas recirculation systems are used for recirculation cooling of the hot gases of an internal combustion engine (not illustrated) before they are combined with the intake air and fed to the intake tract of the internal combustion engine. The exhaust gas radiator 1 is composed of a housing jacket 2 which holds in it a nest of pipes which are composed of exhaust gas pipes 3. The ends of the pipes 3 are fastened to a pipe plate 4 which is itself welded to the housing jacket 2. The housing jacket 2 has a sliding fit 5 which is composed

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of an outer ring 6 and an inner ring 7.

Fig. 2 shows the exhaust gas radiator 1 according to fig. 1 in a sectional view, i.e. in a longitudinal section through the exhaust gas pipes 3 which are held at the ends in the two pipe plates 4 and 5, i.e. are, for example, connected to the pipe plates 4, 5 by means of a welded connection. Said pipe plates 4, 5 are connected at the circumference to the housing jacket 2 in a secure and fluid-tight fashion by means of welded connections 6, 7. The exhaust gas of the internal combustion engine (not illustrated) flows through the exhaust gas pipes 3, and coolant, which is removed from the coolant circuit (not illustrated) of the internal combustion engine, flows around the exhaust gas pipes 3, i.e. through the gaps 8 left between them. The connections for the inflow and outflow of the coolant for the housing jacket 2 are not illustrated for the sake of simplicity. The housing 2 is composed of two housing parts 2a and 2b which have a joint 9. In the region of this joint 9, the housing part 2b which is arranged to the right in the drawing has a smaller cross section than the housing part 2a which is illustrated to the left in the drawing. An outer ring 10 is attached to the housing part 2a, and an inner ring 11 is attached to the housing part 2b. The outer ring 10 and the inner ring 11 together form the sliding fit 5, which is illustrated as a detail in fig. 2c.

Fig. 2c shows the end regions of the housing parts 2a, 2b in the region of the joint 9, the end sides of the housing parts 2a, 2b being spaced apart from one another by a gap s. The inner ring 11 is attached to the housing part 2b by bonding and the outer ring 10 is attached to the housing part 2a by means of a bonded connection. The outer ring 10 overlaps the inner ring 11 and forms with it a sliding fit 13. A plastic layer 14 is securely attached to the internal surface of the

outer ring 10 in the region of the sliding fit 13. In contrast, the outside of the inner ring 11 is metallically smooth, for example ground. This results in a low-friction sliding pairing between the plastic layer 14 and the metallic surface of the inner ring 11 for the sliding fit 13. The sliding fit 13 is sealed with respect to the outside, i.e. with respect to the atmosphere, by means of two O rings 15 so that coolant cannot escape to the outside.

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Figs. 2a, 2b show the cross section of the exhaust gas radiator 1 as a view and as a section. It is apparent that the pipes 3 have a rectangular cross section and are at approximately equal distances 16 from one another. Owing to this arrangement of the pipes 3, an approximately rectangular profile with shoulders 2c is obtained for the contour of the housing jacket 2b. The contour of the inner ring 11 is adapted to this somewhat rugged contour which is bent by the shoulders 2c. In contrast, the outer contour 11a of the inner ring is smoothed and has an approximately polygonal profile without severe curvatures, and this surface can therefore be manufactured relatively easily as a smooth surface and can be sealed with respect to the inner surface of the outer ring 10 using simple means such as O rings 15.

The outer ring 10 and inner ring 11, plastic sliding layer 14 and O rings 15 can be manufactured together as a prefabricated unit, i.e. as a prefabricated sliding fit 5, and then connected to the housing parts 2a, 2b by means of the bonded connection already mentioned.

When the exhaust gas radiator 1 is operating, the sliding fit 5 ensures that the housing 2 and the housing parts 2a and 2b can follow the relatively severe expansion of the pipes 3 by moving in relation to one another - thermal stresses and the excessive

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stresses of the components are thus avoided.

Fig. 3 shows a further exemplary embodiment of the invention for a sliding fit, i.e. an exhaust gas radiator 20 of which only the region of the sliding fit is represented as a detail. The exhaust gas radiator 20 has a housing jacket 21 which comprises a coolant region 22 and an exhaust gas region 23. A pipe plate 24 in which exhaust gas pipes 25 are attached, for example by soldering or welding, is arranged inside the housing jacket 21. The pipe plate 24 is adjoined by a hollow cylindrical region which holds in each case one O ring 29, 30 in each of two annular grooves 27, 28. The cylindrical attachment 26 has an outer sliding surface 31 which bears in a sliding fashion against an inner surface 32 of the housing jacket 21 and thus forms a sliding fit 31/32 with the housing jacket 21. The housing 21 is divided by a slot 33 between the two O rings 29, 30. It thus has a left-hand housing part 21a and a right-hand housing part 21b. Both housing parts 21a, 21b are held apart by a constant distance, i.e. the width of the slot 33, by means of spacer sleeves (cf. fig. 4) distributed over the circumference and attachment eyelets 35, 36 which are provided on the housing parts 21a, 21b. The attachment of eyelets 35, 36 and the spacer sleeves 34 are clamped to one another by means of screw or bolt connections (not illustrated). The slot 33 is thus connected to the atmosphere, i.e. the outside of the housing jacket 21.

Fig. 4 shows a section along the sectional plane IV-IV in fig. 3, i.e. through the region of the slot 33 and the spacer sleeve 34. The cross section of the pipes 25 is circular here.

When the exhaust gas radiator 20 is operating, hot exhaust gases flow through the region 23 into the interior of the pipes 25, around which coolant, which

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flows around the inside of the housing jacket 21 flows on the outside, i.e. in the coolant region 22. Said housing jacket 21 is therefore at a lower temperature than that of the exhaust gas pipes 25. The greater
5 degree of expansion of the exhaust gas pipes 25 is compensated by the sliding fit 31/32, i.e. the pipes can expand freely with respect to the housing jacket 21 by means of the pipe plate 24 and the cylindrical attachment 26. The seal between the coolant region 22
10 and exhaust gas region 23 is provided by means of the O rings 29, 30. If one of these O rings were to lose its sealing effect, coolant would leave the region 22 or exhaust gas would leave the region 23 and enter the slot 33 and pass from there to the outside and into the
15 atmosphere. This prevents either exhaust gas entering the coolant region 22 or coolant entering the exhaust gas region 23 and thus causing damage.

Fig. 5 shows a modified exemplary embodiment of the
20 exhaust gas radiator 20 according to fig. 3, i.e. an exhaust gas radiator 40 with a continuous housing jacket 41 and a sliding fit 42 which corresponds to the sliding fit 31/32 of the exemplary embodiment according to fig. 3. An annular groove 45, which has a
25 corresponding annular collar 46 (or an integral bead), is integrally formed between two O rings 43, 44. The annular groove 45 is connected to the atmosphere via a drainage opening 47. The drainage which has been described above for the exemplary embodiment according
30 to fig. 3, i.e. the conduction away of coolant or exhaust gas to the outside is thus possible in the same way. An advantage with this solution is that the housing 41 is in one piece and can thus be manufactured more easily.